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# A STUDY ON PHYSICAL PARAMETERS OF POROUS CONCRETE

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## ABSTRACT

Road construction is a significant part of the construction industry in India .The roads in India is prone to the drainage problem during the rainy season or any other factor throughout the entire year. Thus the sub grade of pavement is severely destroyed by the penetration of water through the surface layer. In this study experimental analysis like compressive strength test, permeability test etc is performed on the pervious concrete to determine the suitability of this concrete to reduce this drainage problem. The result shows that the average compressive strength of pervious concrete is 9.75-11.11N/mm$^2$ and has a permeability of 0.31cms-1 hence this concrete can be used in sideways or pathway or footpath. It has the capacity to stop water clog on the pavement surface and easily drain off the same from sideways.

**KEYWORDS:** Porous, Concrete, Pavement, Drainage, subgrade, pathway.

## 1. INTRODUCTION

Porous concrete is a type of concrete which possess high porosity thereby allowing water to pass through it directly. It can reduce any runoff from a site or refill groundwater. Pervious concrete comprises of large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality.

The term "pervious concrete" is a open-graded material consisting of coarse aggregate, Portland cement, admixtures and water and very little amount of fine aggregate. The combination of these ingredients will produce a hardened material with connected pores, ranging in size from 2 to 15 mm, which allow water to pass through easily. The void content can range from 15 to 35%, with typical compressive strengths of 4 to 25 MPa [1]. The drainage rate of porous concrete will vary with size of aggregate and mixture density, but usually will fall into the range of 81 to 730 L/min/m$^2$. Pervious concrete is widely recognized as a sustainable building material, as it reduces storm water runoff, improves storm water quality, can reduce the impact of the urban heat island effect and allow water seepage which in a way refills the groundwater. It may give urban trees the rooting space they need to grow to full size thus reducing the serious erosion and siltation hazards.

## 2. OBJECTIVE OF STUDY

- To determine the workability of pervious concrete.
- To determine compressive strength of pervious concrete.
- To determine the flexural strength of pervious concrete.
- To determine water permeability of pervious concrete.
- To determine porosity of pervious concrete.

## 3. MATERIALS USED

**Binder material:** Porous concrete binder connects the aggregates and transfer load throughout. Too little binder doesn't give sufficient area to connect thus affecting the concrete strength and durability. On the other hand, too much binder fills in the concrete voids and does not allow the required permeability. Ordinary Portland cement as per IS: 12269-1987[3] was used.

**Coarse aggregate:** The coarse aggregate used for the experiment was 10 mm crushed gravel. The specific gravity of this aggregate is 2.69, crushing value 20.50% as per IS 6461(Part 1):1972[4].

**Fine aggregate:** Fine aggregate have not been used so as to get maximum porosity.

**Admixtures:** Chemical admixtures (retarders) are commonly used.

## 4. EXPERIMENTAL ANALYSIS

### 4.1 General

Void content: 18-35%

Strength : 28-281 kg/cm$^2$

Infiltration rate: 80-720 litre per min per sqm

Cement content: 267-415 kg/m$^3$

w/cm ratio : 0.26 – 0.40

Coarse aggregate: 9.5 – 19mm

Little to no fine aggregate (less than 10% of wt. of total aggregate) Just enough cementitious paste to coat the coarse aggregate.

### 4.2 Pervious Concrete Mix Design

Pervious concrete uses same materials as conventional concrete, except that there are usually no or little fine aggregates. The coarse aggregate used is kept fairly uniform in size (most common is 3/8 inch, however sizes can vary from ¼ inch to ½ inch. Blended or Ordinary Portland cements can be used in porous concrete. Water reducing admixtures and retarders can be used in pervious concrete.

General Issues encountered compared to standards concrete are:

i. Long mixing time in the batching plants (about 20 min)

ii. Poor workability, very dry mix, difficult for placing

iii. Amount of water used in mix is important as same as standards concrete

iv. If too much water used, segregate is expected, usually higher than standards concrete

v. If too little water is used, not easy to mix, balling of mix in the mixer.

**Table 1: Typical mix design of Pervious Concrete as suggested by ACI 522R-10**

| Materials | Proportions (Kg/m3) |
|---|---|
| Cement (OPC or blended) | 270 to 415 |
| Aggregate | 1190 to 1480 |
| Water: cement ratio (by mass) | 0.27 to 0.34 |
| Fine: coarse aggregate ratio (by mass) | 0 to 1.1 |
| Chemical admixtures (retarders) are commonly used. | |

**Table 2: Optimised mix design of Pervious Concrete (with 19mm aggregates, No Sand).**

| Mix | Cement (kg) | Aggregate (kg) | Water (kg) | A/C Ratio | W/C Ratio |
|---|---|---|---|---|---|
| I | 10 | 40 | 3.0 | 4.0 | 0.30 |
| II | 9.52 | 40 | 2.8 | 4.2 | 0.29 |
| III | 8.89 | 40 | 2.4 | 4.5 | 0.27 |

### 4.3 Mixing

All dry materials were mixed in the pan mixer for about three minutes. The liquid component of the mixture was added at the end of dry mixing and wet mixing was continued for another four minutes.

**Figure 1 Dry mixing of ingredient**

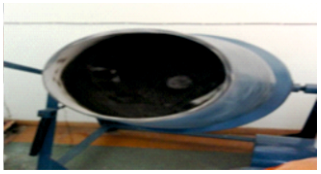

**Figure 2 Mixing of concrete**

**4.4 Casting of slabs:**
A slab of 1m x 1m x 0.05m was casted in different portions, such that it can easily handle the mixture. Slabs were used to test the permeability, porosity, void content and seepage through it.

**Figure 3 Casting of slabs**

**4.5 Curing of slabs**
Pervious concrete slab, beam and cubes should be spray cured. After 24 hours of casting the slab/beam/cube were water sprayed and then covered with polythene for 7 days as shown in fig 4

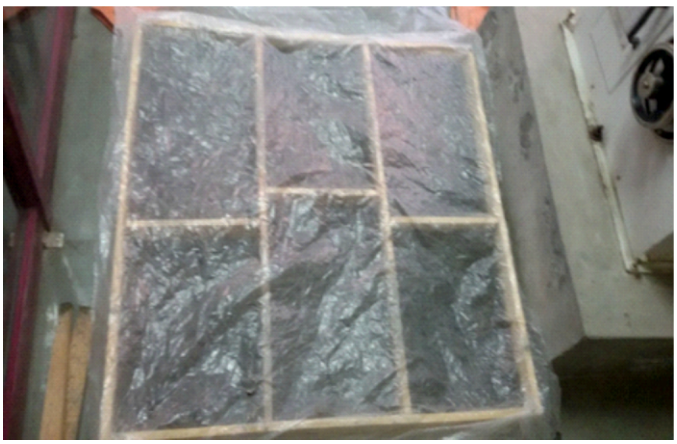

**Figure 4 Curing of slabs**

**5. OBSERVATION AND RESULT**
**5.1 AGGREGATE TEST:**
**5.1.1 Flakiness Index and Elongation test:**
The flakiness index of aggregate is the percentage by weight of particles whose least dimension is less than three fifth (0.6) times of their mean dimensions. The test is not applicable to aggregate size smaller than 6.3 mm.

The elongation index of aggregate is the percentage by weight of particle whose greatest dimension is greater than one and four fifth (1.8) times their mean dimension. The elongation test is not applicable to size smaller than 6.3mm.

**Table 3: Flakiness Index and Elongation Index**

| Sieve Size (mm) | Weight of 200 piece of aggregate in gm | Weight of flaky aggregate (w) gm. | Flakiness index (%) | Weight of elongated aggregate (x) gm | Elongated index(%) |
|---|---|---|---|---|---|
| 50-40 | - | - | - | - | - |
| 40-25 | - | - | - | - | - |
| 25-20 | - | - | - | - | - |
| 20-16 | - | - | - | - | - |
| 16-12.5 | 30200 | 2980 | 9.87 | 8050 | 26.65 |
| 12.5-10 | 11800 | 835 | 7.07 | 3370 | 28.55 |
| 10-6.3 | - | - | - | - | - |

**Result:**
The flakiness index of the given sample of aggregate is 8.47%.

The elongation index of the given sample of aggregate is 27.6%.

**5.1.2 Specific gravity test and water absorption test:**
Apparent Specific Gravity = Sa = 2.872

Water Absorption, = WA = 0.361

**5.1.3 Aggregate Impact Test:**
Aggregate impact value =26%

**5.1.4 Aggregate Crushing Value:**
Aggregate crushing value =24.84%

**5.2 Workability Test:**
**5.2.1 By Compaction Factor Apparatus: -**
In general, a gap-graded conventional porous concrete (CPC) or "no fines" concrete, where the fine aggregate is omitted entirely and a uniform size of coarse aggregate is used with low water-cement ratio less than 30%, shows poor workability, needs vibration equipment for proper compaction and curing for the production of precast products, and for drainage pavement application.

**Figure 5:- Compaction factor apparatus**

**Calculation:**
Compaction factor = weight of the partially compacted concrete / weight of fully compacted concrete.

Weight of the partially compacted concrete = 15.240 kg

Weight of fully compacted concrete = 17.305kg

**Result:** Compaction factor =15.240/17.305 = 0.88

**Conclusion:** Low workable mix.

**5.2.2 By Slump Test:**

**Figure 6: Slump test**

**Result:** Slump = 25mm

**Conclusion:** Low Workable.

**5.3 compressive Strength Test Of Concrete:**

Compressive strength of concrete was done using cubical moulds of size 15 cm x 15cm x 15 cm. Each of the compressive strength test data points plotted in various graphs or stated in various Tables corresponds to the mean value of the compressive strengths of three test concrete cubes.

**Figure 7: Compressive Strength test using CTM.**

**Result:**

**Table 4: Compressive strength**

| Cube no. | Compressive strength (N/mm$^2$) | |
|---|---|---|
| | Steam curing | Spray curing |
| 1 | 10 | 11 |
| 2 | 10 | 12 |
| 3 | 9 | 12 |
| 4 | 10 | 11 |
| Average | 9.75 | 11.5 |

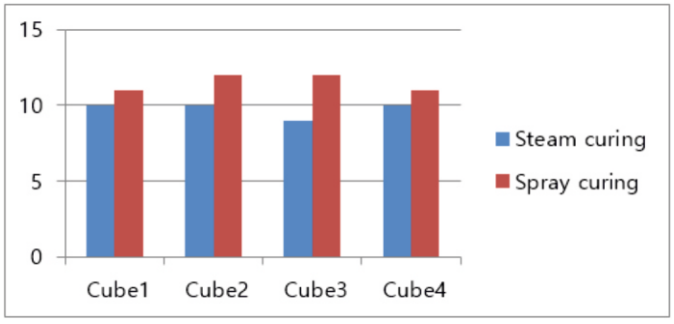


**Figure: 8 Comparison of compressive strength of steam cured and spray cured pervious concrete cubes**

Average compressive strength of steam cured cubes = 9.75 kN/mm$^2$

Average compressive strength of spray cured cubes = 11.5 kN/mm$^2$

**5.4 Permeability:**

Permeability of pervious concrete is defined as the ability of concrete to pass water through it. The flow rate through pervious concrete depends on the materials and placing operations. Typical flow rates for water through pervious concrete are 3gal/ft²/min (288 in./hr, 120 L/m²/min, or 0.2 cm/s) to 8 gal/ft²/min (770 in./hr, 320 L/m²/min, or 0.54 cm/s), with rates of up to 17 gal/ft²/min (1650 in./hr, 700 L/m²/min, 1.2 cm/s)

**Figure 9: shows an arrangement to measure permeability**

**Calculation:**

As per Darcy's law: - Discharge(Q) is proportional to the Hydraulic gradient (i)

Q = KiA

Where 'Q' is rate of flow in cm$^3$s$^{-1}$

K is permeability of slab in cms$^{-1}$

A is the area of slab in consideration in cm$^2$

**Table 5: Values obtained from Permeability apparatus**

| Property | Value |
|---|---|
| Flow Rate Through Bucket (Without Slab) in Time 100sec | 40 cm$^2$s$^{-1}$ |
| Height if Water Collected in Container Through Slab in 100 Sec | 8.5 cm |
| Length of Slab | 14cm |
| Area of Slab in Consideration | 213.82 cm$^2$ |

So, Q = kiA

40 = K x 8.5/14 x 213.82

**Result:** K = 0.31 cms$^{-1}$

## 6. CONCLUSION

The Pervious concrete having permeability of 0.31 cms$^{-1}$ allows water to pass through it. It is composed of aggregates in the range of 19– 9.4 mm only with flakiness index of 8.47%.and the elongation index is 27.6%. Also the density of this concrete is less than the conventional concrete because fine aggregates were not used. The average compressive strength of steam cured and spray cured pervious concrete was found to be 9.75 kN/mm$^2$ and 11.5 kN/mm$^2$ respectively which indicates that the compressive strength of steam cured concrete is 15.21 % less than that of spray cured. Thus pervious concrete pavements are a very cost-effective and environment friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role in road construction. It is an ideal solution to control storm water, re-charging of ground water, flood control at downstream and sustainable land management.

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